

Nanostructure Multilayer Capacitors for Power Electronic Applications

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Abstract

Power electronics applications are currently limited by capacitor size and performance. We anticipate incremental improvements with existing capacitor technologies, but require significant performance advances in energy density and overall performance to meet the technical needs of the applications that are important for U.S. economic competitiveness. To meet this need, one application, the Power Electronic Building Block (PEBB), promises a second electronics revolution in power electronic design. High energy-density capacitors with excellent electrical thermal and mechanical performance represent an enabling technology in the PEBB concept. High-power energy storage for electric and hybrid vehicles is also an issue which may best be addressed by capacitors.

We use Lawrence Livermore National Laboratory's (LLNL's) *nano-structure multilayer* technologies to fabricate high-voltage, high energy-density capacitors. Our controlled sputter deposition techniques are capable of synthesizing extraordinarily smooth sub-micron-thick layers of dielectric and conductor materials. These nanostructure multilayer capacitors (NMCs) are inherently solid state, exhibiting superior mechanical and thermal properties when compared with conventional electrolytic, oil-filled, or polymer constructions. Their compact, flat profiles are well-suited to surface mounting and to integration into power semiconductor device packages, offering performance, volume, and cost advantages over discrete capacitors. We have demonstrated high-voltage (1.2 kV) capacitors with high energy density (10 J/cm^3), low-loss ($\tan \delta < 0.001$), and excellent high-frequency characteristics using metal-oxide dielectrics. Additional dielectric and conductor material combinations with potentially higher energy density are currently being investigated and developed.

Long-term plans, with sufficient funding and in collaboration with industrial partners, include continued dielectric materials research, engineering design and evaluation for power electronics applications, building a prototype manufacturing capability for NMC production, designing a full-scale manufacturing system, and shifting this technology to industry for commercialization.

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